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RESEARCH MEMORANDUM

for the

Air Materiel Command, U. S. Air Force

MEASUREMENTS IN FLIGHT OF THE LONGITUDINAL-STABILITY CHARACTERISTICS OF A REPUBLIC YF-84A AIRPLANE (ARMY SERIAL NO. 45-59488) AT HIGH SUBSONIC MACH NUMBERS

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SUMMARY

A brief investigation was made of the longitudinal-stability characteristics of a YF-84A airplane (Army Serial No. 45-59488). The airplane developed a pitching-up tendency at approximately 0.80 Mach number which necessitated large push forces and down-elevator deflections for further increases in speed. In steady turns at 35,000 feet with the center of gravity at 28.3 percent mean aerodynamic chord for normal accelerations up to the maximum test value, the control-force gradients were excessive at Mach numbers over 0.78.

Airplane buffeting did not present a serious problem in accelerated or unaccelerated flight at 15,000 and 35,000 feet up to the maximum test Mach number of 0.84. It is believed that excessive control force would be the limiting factor in attaining speeds in excess of 0.84 Mach number, especially at altitudes below 35,000 feet.

INTRODUCTION

A brief longitudinal-stability and -control investigation was conducted on a Republic YF-84A airplane to determine if any serious problems associated with high Mach number flight would be encountered. It was known prior to this investigation that more or less violent pitch-ups at high Mach numbers had been experienced

[redacted]

on these airplanes (reference 1). For this investigation, emphasis was placed on exploring the Mach number range from 0.75 to the maximum Mach number deemed practicable.

Since maintenance difficulties limited the test flights to five, including the airspeed calibration flights, and a long delay was anticipated before the Mach number range could be extended beyond M = 0.84, the data obtained in this exploratory phase of the program was analyzed and is presented herein.

Low-speed wind-tunnel data on a model of the XP-84 is available in reference 2.

DESCRIPTION OF THE AIRPLANE

The YF-84A airplane is a single-seat, jet-propelled, fighter-type airplane. A general three-view drawing is shown in figure 1. The principle dimensions of the airplane are given in table I. Figures 2 and 3 are photographs of the airplane as tested.

No tests were made with the tip tanks installed.

TEST APPARATUS AND PRECISION

Standard NACA film recording instruments were used to measure all of the quantities presented in this report. The airspeed installation was calibrated and corrected for the blocking effect of the airplane and of the airspeed head itself.

The fuel consumption sequence was such that the nominal test center-of-gravity position was approximately 28.3 percent M.A.C.

The following quantities were estimated to be known within the given values:

Mach number	± 0.005
Elevator angle, degrees	± 0.2
Elevator force, pounds	± 2 under 30 pounds ± 5 over 30 pounds
Normal acceleration, g	± 0.05

[redacted]

TEST RESULTS AND DISCUSSION

The flight data were obtained with the airplane in steady, unaccelerated flight, wings level, at altitudes of 15,000 and 35,000 feet, and in steady turns at 35,000 feet. The results of these tests are presented in figures 4 to 6.

Balance Changes Due to Mach Number

Steady unaccelerated flight.- The variation with Mach number of the elevator control force and the elevator deflection required for balance in steady unaccelerated flight are presented in figure 4. These data indicate a large nose-up change in balance occurring at approximately 0.80 Mach number. This appears to be purely a Mach number effect, as shown by the similarity of the curves of figure 4 at both 15,000 and 35,000 feet. Any effects of aeroelasticity would be evidenced by sizable deviations of the two curves below 0.79 Mach number.

The pilot experienced no particular difficulty, other than the increasing of the control force with Mach number, in flying to the highest test Mach number at 35,000 feet. It is evident from figure 4 that only a small increase in Mach number would be possible at this altitude and trim tab setting before the control force would become excessive. It appears that to attain higher Mach numbers it would be necessary to fly at altitudes above 35,000 feet. At 15,000 feet, the control force at 0.825 Mach number was excessive (80 lb) and effectively limited the maximum speed to which the airplane could be flown with the trim tab set for trim at 0.795 Mach number.

Steady turning flight.- The variation of the elevator deflection and the elevator control force with normal acceleration as measured in steady turning flight at various test Mach numbers is presented in figure 5. The airplane was trimmed at 1g for each test Mach number with the exception of the test Mach numbers of 0.83 and 0.84. The trim tab was not powerful enough to trim at 1g for these speeds, so maximum nose-down trim was used.

Figure 5 shows that the normal acceleration factor increased approximately proportional to the elevator control force up to about 3.0g. Above this point the force curve slope dropped off and became negative at approximately 3.3g for the higher Mach numbers. However, the control forces did not change sign over the range tested.

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The elevator control-force gradients over the Mach number range of 0.70 to 0.84 at three normal accelerations are given in figure 6. With the center-of-gravity position at approximately 28.3 percent M.A.C., the control-force gradients exceed the maximum allowable gradient, based on a design load factor of 7.33g (reference 3, section D-4-2), at Mach numbers over 0.78.

Airplane Buffeting

A general buffeting of the airplane was noticed at Mach numbers above 0.81. Up to the maximum Mach number attained (M = 0.84) in accelerated or unaccelerated flight, the intensity of the buffeting was mild to moderate and at no time was it considered serious by the pilot.

No aileron "buzz" as such was observed. A general buffeting of the flaps and ailerons was noticed but it was believed to be the result of a loose-fitting aileron tab hinge and improper installation of wing flap stops. Considerable "sucking-in" of the flaps and ailerons was noticed. This surface distortion appeared to accompany changes in airplane angle of attack and resulted in slight changes in airplane trim that were apparent to the pilot.

CONCLUSIONS

The following characteristics were noted during a brief flight investigation of the longitudinal-stability characteristics of a YF-84A airplane (Army Serial No. 45-59488) at altitudes of 15,000 and 35,000 feet:

1. In steady flight, wings level, the airplane experienced a pitching-up tendency at a Mach number of approximately 0.80. Large push forces and down-elevator angles were required for further increases in Mach number. The push forces became excessive before the airplane buffeting became serious. It is believed that excessive elevator control force would be the limiting factor in attaining Mach numbers above 0.84, especially at the lower altitudes.

2. The elevator stick-force gradients at normal accelerations up to the maximum test value exceeded the maximum allowable gradient at Mach numbers over 0.78.

3. General buffeting of the airplane was noticeable at Mach numbers over 0.81. However, the buffeting was mild to moderate and,

in the pilot's opinion, was not serious up to the maximum speed attained (M = 0.84) at either altitude.

Ames Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Moffett Field, California.

REFERENCES

1. Sullivan, J.B.: Compressibility Effects on the Flight Characteristics of the XP-84-2 Airplane in Dives to .815 Mach Number. Republic Aviation Corp. Flight Test Memo Rep. No. 580, XP-84-2, Sept. 11, 1946.

2. Tucker, Warren A., and Goodson, Kenneth W.: Tests of a 1/5-Scale Model of the Republic XP-84 Airplane (Army Project MX-578) in the Langley 300 mph 7- by 10-Foot Tunnel. NACA MR No. L6F25, 1946.

3. Anon.: Specification for Stability and Control Characteristics of Piloted Airplanes. Spec. No. SR-119B, Bur. Aero., Navy Dept.; and Spec. No. 1815B, USAF Air Materiel Command.

[redacted]

TABLE 1.- PRINCIPLE DIMENSIONS OF THE REPUBLIC YF-84A AIRPLANE
(ARMY SERIAL NO. 45-59488)

Type	jet-propelled fighter
General	
Span	36 ft 5 in.
Length	36 ft 10-1/2 in.
Height (nose wheel on ground)	12 ft 7 in.
Wings	
Area	260 sq ft
Aspect ratio	5.1
Taper ratio	0.57
Dihedral (top surface)	4°
Incidence (root section)	0°
Incidence (tip section)	-2°
Sweepback at leading edge	6°15'
Mean aerodynamic chord (M.A.C.)	7.39 ft
Airfoil section	Republic R-4, 45-1512-9
Trailing-edge angle	17.5°
Total aileron area	25.0 sq ft
Total flap area	28.9 sq ft
Total dive recovery flap area	2.8 sq ft
Horizontal tail	
Area	48.5 sq ft
Span	14 ft 11-5/16 in.
Aspect ratio	4.6
Elevator area (aft of hinge line)	13 sq ft
Root-mean-square chord of elevator	0.99 ft
Incidence	0°
Dihedral (jig reference line)	5°
Airfoil section	Republic R-4, 40-010
Trailing-edge angle	14°
Vertical tail	
Area	30 sq ft
Rudder area (aft hinge line including tab)	7.4 sq ft
Height above fuselage center line	8.1 ft
Root-mean-square chord of rudder	1.21 ft
Airfoil section	Republic R-4, 40-010
Trailing-edge angle	14°
Weight and balance	
Normal gross weight	12,500 lb
Wing loading	48 lb/sq ft
Center-of-gravity range	22 to 31% M.A.C.
Normal center of gravity	26.45% M.A.C.
Nominal test center of gravity	28.3% M.A.C.

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FIGURE LEGENDS

Figure 1.– Republic YF-84A airplane.

Figure 2.– Three-quarter front view, YF-84A airplane.

Figure 3.– Three-quarter rear view, YF-84A airplane.

Figure 4.– Control forces and elevator angles required for balance at various Mach numbers. Normal acceleration 1g; c.g., 28.3 percent M.A.C.; YF-84A airplane.

Figure 5.– Variation of control force and elevator angle with normal acceleration in turns at 35 000 feet. C.g., 28.3 percent M.A.C.; YF-84A airplane.

Figure 6.– Elevator control-force gradients in turns at three normal accelerations. Altitude, 35,000 feet; c.g., 28.3 percent M.A.C.; YF-84A airplane.

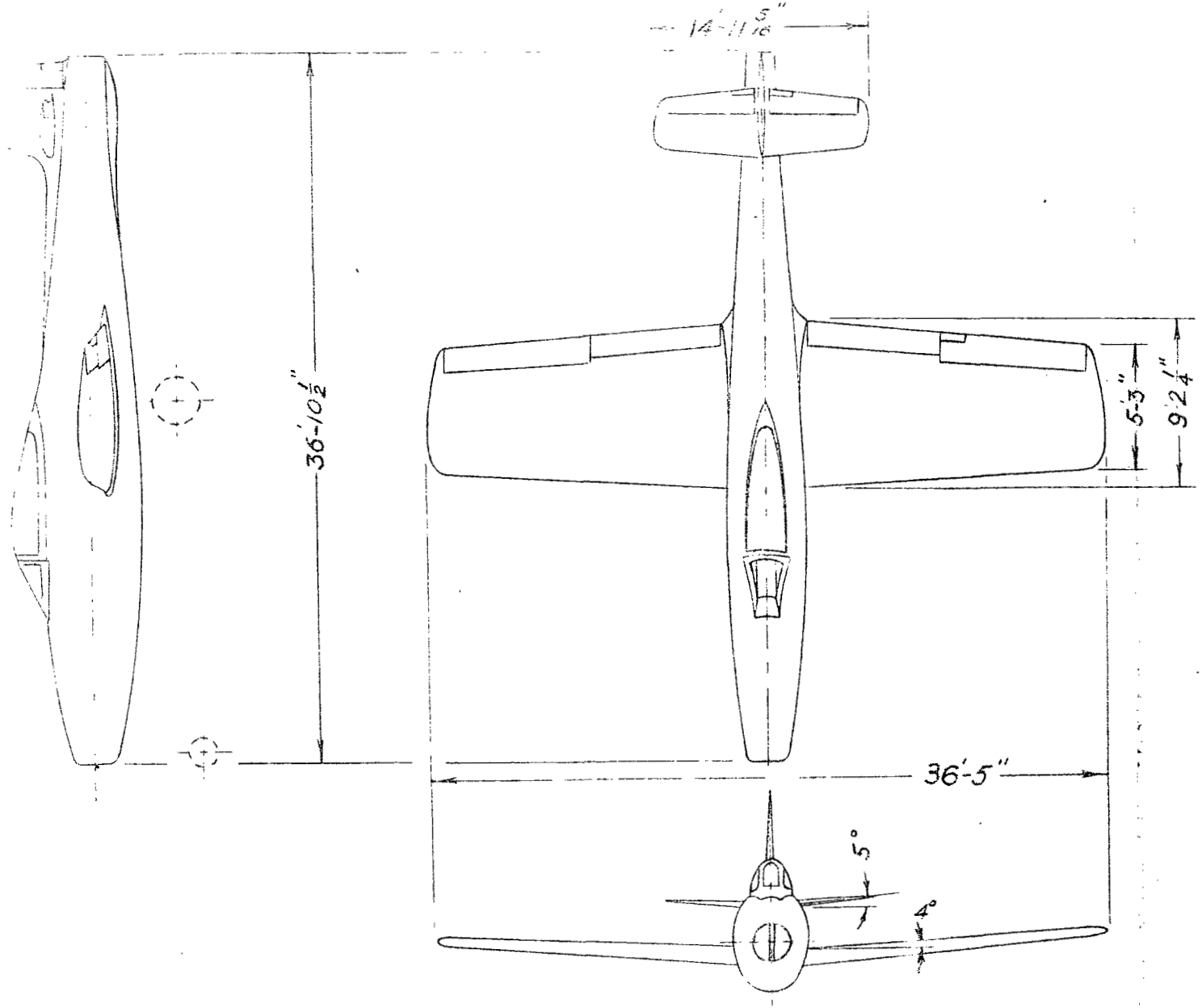

Figure 1.- Republic YF-84A airplane.

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Figure 2.- Three-quarter front view, YF-84A airplane.

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Figure 3.- Three-quarter rear view, YF-84A airplane.

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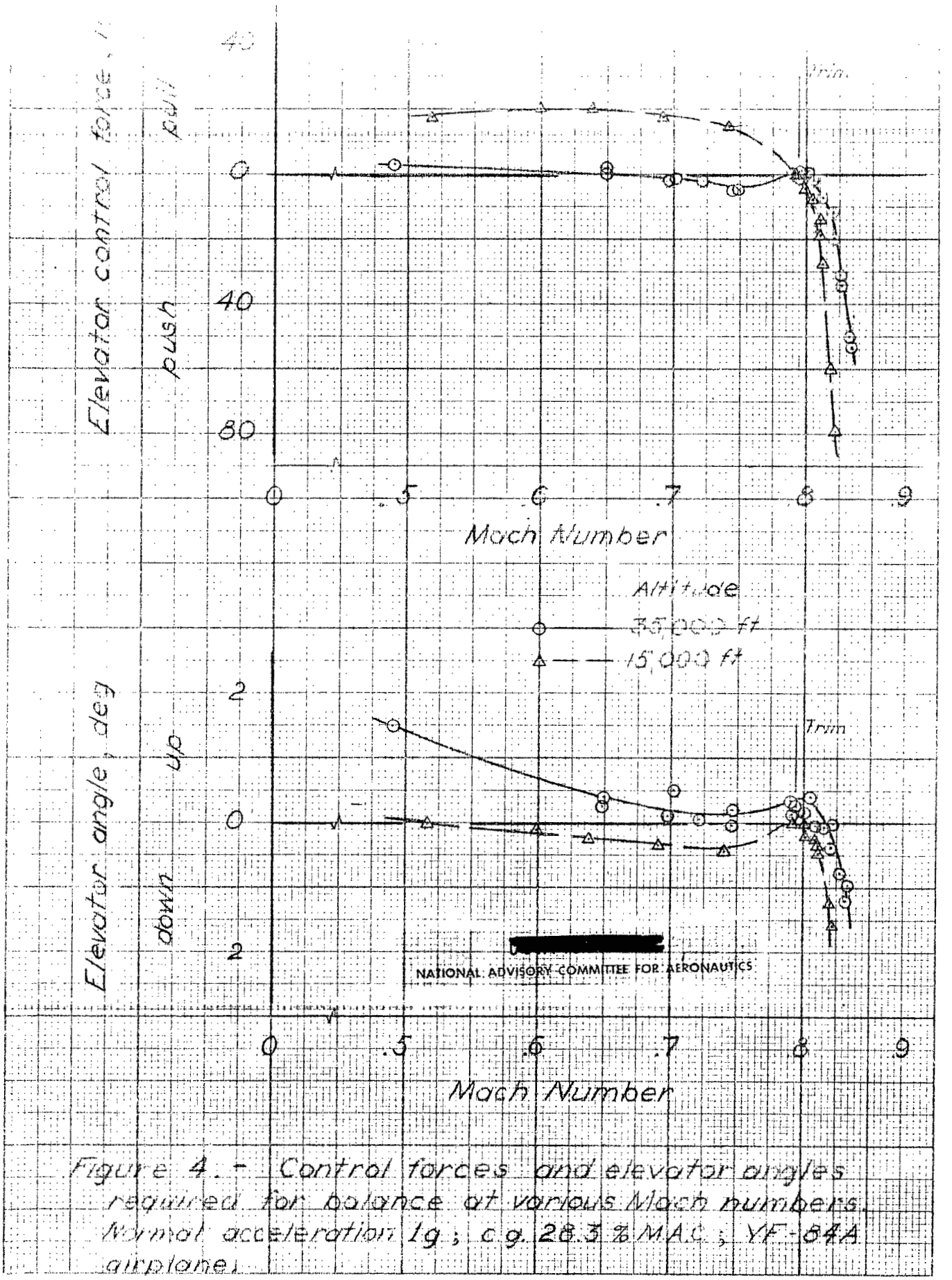

Figure 4.- Control forces and elevator angles required for balance at various Mach numbers. Normal acceleration 1g; c.g. 28.3 % MAC; YF-84A airplane.

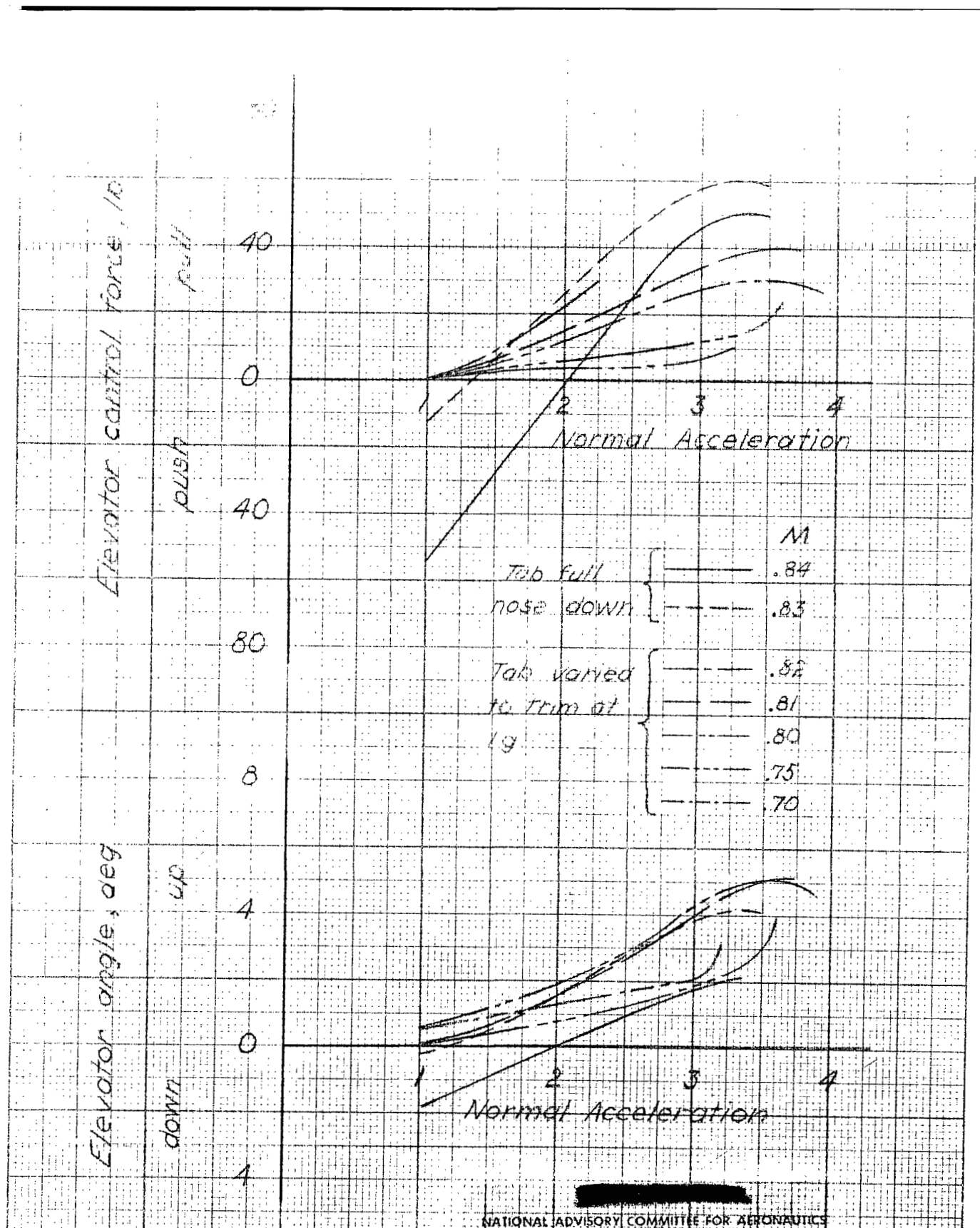

Figure 5.- Variation of control force and elevator angle with normal acceleration in turns at 35,000 feet. C.g., 28.3% MAC; YF-84A airplane.

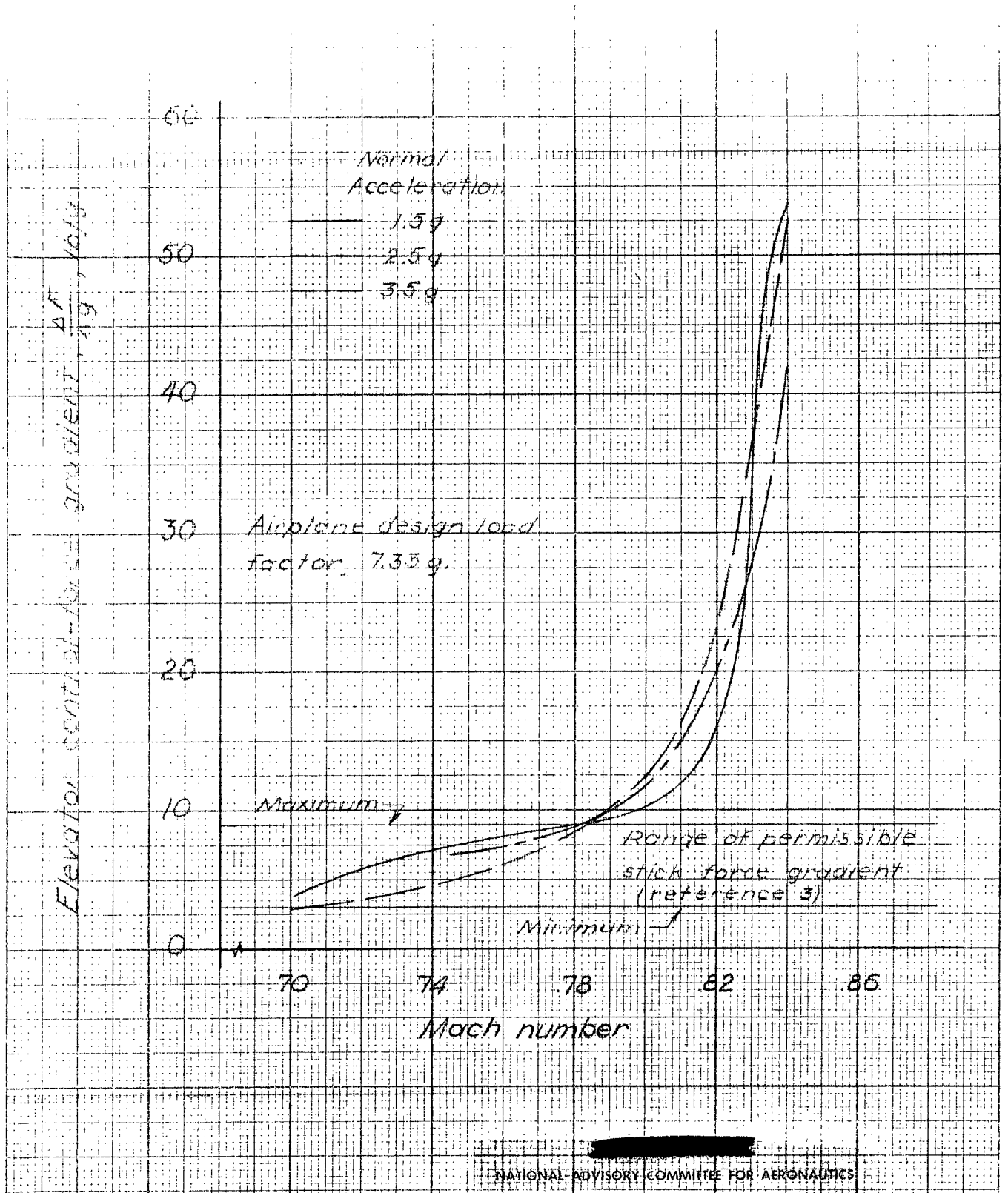

Figure 6.- Elevator control-force gradients in turns at three normal accelerations. Altitude, 35,000 feet; c.g., 28.3% M.A.C.; YF-84A airplane.

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